USING CLASSROOM VIDEO TO IDENTIFY DEVELOPMENT OF TEACHER KNOWLEDGE

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Teacher knowledge for teaching statistics through investigations at the primary school level can be analyzed using a framework based on a combination of statistical thinking components and teacher knowledge. This paper focuses on the question of whether growth of teacher knowledge occurs through teaching, and if so, what types of teacher knowledge. In this research, classroom video and stimulated recall interviews with the teachers provided the main data, both of which were analyzed using the framework for teacher knowledge for teaching statistics. Growth in some categories of teacher knowledge was identified, but not for other categories. Implications for teacher education are discussed.

INTRODUCTION

The goals of teacher professional development programs include the enhancing of teacher professional knowledge. To determine the success or otherwise of the professional development, any change in teacher knowledge would need to be identified, particularly in relation to the use of that knowledge within the context of the classroom. One of the questions that arises is how any change in teacher knowledge can be identified. This paper outlines research conducted in four primary school classrooms using video as a primary data source, and how teacher knowledge for teaching statistics through investigations was mapped onto a framework, from which it was possible to identify which aspects of teacher knowledge developed.

LITERATURE REVIEW

Teacher knowledge

Teacher knowledge has been examined in various ways, particularly influenced by the work of Shulman (1986, 1987). Since that time, various categorizations of teacher knowledge have been described, with significant work in the mathematics education literature from Ball and other colleagues (for example Ball, Thames, & Phelps, 2005; Hill, Schilling, & Ball, 2004). Building on from this work, and incorporating the statistical thinking components (Wild & Pfannkuch, 1999), a teacher knowledge framework for teaching statistics was developed (Burgess, 2006). The framework consists of a matrix with four categories of teacher knowledge (common knowledge of content, specialized knowledge of content, knowledge of content and students, and knowledge of content and teaching) against seven components of statistical thinking (need for data, transnumeration, consideration of variation, reasoning with models, integration of statistical and contextual knowledge, use of the investigative cycle, and use of the interrogative cycle; another aspect of statistical thinking was excluded from the framework). Consequently 28 ‘cells’ of the matrix had the potential to be identified and described in relation to both a teacher knowledge category and a component of statistical thinking. This framework was used to describe aspects of teacher knowledge that are needed by teachers to teach statistics through investigations (Burgess, 2009).

Knowledge growth

Along with defining and describing teacher knowledge, it is important to consider how teacher knowledge develops. Shulman (1986) suggests that it starts with subject matter knowledge, and from there, pedagogical content knowledge (aspects of subject matter knowledge that are specifically needed for teaching) arises from a ‘transformation’ of subject matter knowledge. Pedagogical content knowledge includes knowledge of ways of representing ideas for learners to make sense of concepts and knowledge of the common challenges for learners or common misconceptions. Of the four categories of teacher knowledge listed earlier, the last two, namely knowledge of content and students and knowledge of content and teaching, are components of

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pedagogical content knowledge. Some debate about the development of pedagogical content knowledge, particularly as it applies to primary school teachers, is based on the fact that Shulman's research was with secondary teachers, who are specialists and therefore generally accepted as having a higher level of subject matter knowledge than primary teachers.

Classroom based research

There are strong arguments for conducting research on teacher knowledge in the classroom in which that knowledge is needed. Through such classroom-based research, the way in which the knowledge is actually used by teachers can be the focus for the research (Ball, Lubienski, & Mewborn, 2001; Mewborn, 2001). This also gives the opportunity for exploring how teachers deal with the unplanned but 'teachable moments' that arise within lessons (Friel & Bright, 1998; Heaton & Mickelson, 2002). Also, situations in which a teacher's current pedagogical content knowledge is inadequate can be explored (Ball & Bass, 2000). Furthermore, research in the classroom has the potential to investigate the growth of teacher knowledge.

Research questions

The research questions that this paper addresses are: Does teacher knowledge grow during the course of teaching? If so, what types of teacher knowledge grow? What are the conditions or events that lead to the growth of teacher knowledge?

METHODOLOGY

To consider the growth of teacher knowledge, some thought needs to be given to what is knowledge, and the conditions that lead to knowledge growth. A post-positivist realist perspective on knowledge, based on Popper's ideas (Popper, 1985; Swann, 2003) argues that knowledge exists in an objective sense, and that therefore it is testable and open to refutation. Popper suggests that knowledge grows through a process of trial and error elimination – a problem is recognized, a trial solution is proposed and is subject to the elimination of error, and a new problem can possibly emerge (Popper, 1979). Swann (1999b) further describes this as the 'logic of learning', and discusses it in terms of the mismatch that occurs between current ideas and experience.

To use video for researching teacher knowledge, it must be determined what should be filmed. Schoenfeld (1998) justifies that although the students are active participants in the classroom, for research on teacher knowledge a focus on the teacher is sufficient, as it explains a significant proportion of what takes place in the classroom. Consequently, the videoing of the teacher is considered to be an appropriate data collection tool. A sequence of the first four or five lessons involving statistics investigations were videoed, and episodes from the videos were selected by the researcher for further exploration through stimulated recall discussions with the relevant teacher. These 'critical incident' episodes (Lyle, 2003) provided the basis for a rich discussion around the situations from the classroom. The focus of the selected episodes was on teacher explanations, responses to students' questions or answers, and discussions with individual students or the whole class; these episodes were selected because of their potential links to the teacher knowledge framework.

Four teachers who were early in their career participated in the research. All taught an upper primary school class (from Years 5 to 8, i.e., from about 9 year old through to 13 year old students). The four teachers developed their lessons from the same unit of work, which introduced the students to investigations using multivariate datasets, the first of which contained four category variables, through to one that contained one category and three numeric variables.

RESULTS

The classroom video as well as the audio recordings of the stimulated recall discussions provided the source of data for coding in relation to the cells of the teacher knowledge framework. Some episodes resulted in cells of the framework being identified as that component of knowledge being used, while other episodes indicated knowledge that could have been used but was not in evidence.

Evidence for the growth of teacher knowledge

The most common type of teacher knowledge to grow during the teaching was that of *knowledge of content and students*. This category of knowledge includes the ability to anticipate student errors and misconceptions, to interpret incomplete student thinking, to predict how students will handle specific tasks, and what students will find interesting and challenging. Often, the teachers did not know of or expect the areas in which the students would be challenged. Therefore, when these situations arose, the teachers realized the difficulties that the students were having, and as a result the teachers' *knowledge of content and students* developed, in relation to a particular component of statistical thinking.

The classroom video revealed a number of situations in which the teacher found something unexpected in relation to students' investigations with the data, and the stimulated recall interview provided the opportunity to further discuss and elaborate these with the teacher. This situation corresponded to a mismatch (Swann, 1999a) between the teachers' ideas about students' handling of statistics and the actual experience–the teachers had not expected that the students would struggle with some aspect of statistics. For example, when the students had difficulty with sorting the cards that contained the data about each case in the dataset, the teachers' *knowledge of content and students: transnumeration* developed, as they did not anticipate that this would be a challenge for the students. In particular, the teachers were surprised that numeric data presented more challenge for students than category data.

Within the *knowledge of content and students* category of teacher knowledge, some of the teachers developed the knowledge that students are challenged with handling bivariate data in comparison with univariate data. This results in the students having difficulty with investigating relationships between the two variables. When students can handle such bivariate data appropriately, they are then capable of investigating comparisons between groups. For a teacher to recognize the challenges for students to compare groups of data is part of *knowledge of content and students: reasoning with models*, which was another component of knowledge that teachers developed while teaching.

A different category of teacher knowledge, namely *specialized knowledge of content*, was found to sometimes develop while teaching. This category of knowledge includes knowledge in relation to being able to determine, from a statistical point of view, whether a student's unconventional answer or explanation is reasonable or correct, or being able to give a statistical explanation for something for some aspect related to statistical investigations. For example, one teacher recognized the challenge that a student was having with explaining what his group were intending to investigate in the dataset; the teacher's *specialized knowledge of content: interrogative cycle* developed, as the teacher attempted to make sense of whether the question for investigation was feasible for the given data. This situation represented a mismatch between what the teacher expected of the students and the current experience, and thus corresponded to a problem being recognized in regard to the teacher's knowledge. The teacher's trial solution to this problem involved scaffolding the student's development of questions for their investigations, thereby further developing the teacher's knowledge.

For the classroom episodes in which the teachers' knowledge of content and students developed, most related to the teachers becoming aware of the areas of statistical investigations that were more of a challenge for students than the teachers had realized. As a consequence of the development of this knowledge, the teachers were then often faced with the realization that they had inadequate knowledge of content and teaching in relation to the new knowledge of content and students. They did not have the knowledge of what to do, from a teaching perspective, to help the students overcome their difficulties. So in relation to Popper's theory of learning, the teachers were aware of a mismatch between their current knowledge of content and teaching and the current experience of realizing that such knowledge was needed in these situations. The tentative solution to the problem was that the teacher had nothing appropriate to replace their inadequate knowledge. In other words, the status quo with regard to knowledge of content and teaching was the tentative solution adopted by the teacher.

Some video episodes and the subsequent stimulated recall interviews revealed that once some knowledge of content and students developed, the teacher realized there was a need for a different teaching approach. In other words, there was recognition that the current knowledge of

content and teaching was inadequate. In contrast with the situations described above, where the teacher had nothing to replace their newly recognized inadequate knowledge of content and teaching, sometimes teachers devised a tentative solution to their problem as a way of helping the students learning. For example, one teacher, after realizing there was a need to help students consider two variables simultaneously rather than focus on only one variable, drew a diagram on the board to illustrate some of the possible ways of linking two variables to investigate relationships in the data. This was his new *knowledge of content and teaching: transnumeration* in response to the new *knowledge of content and students: transnumeration*. He soon realized that this tentative solution was not a successful representation for the students and that another problem existed for which another tentative solution would be required. In contrast to this, another teacher's response with regard to her new *knowledge of content and students: transnumeration* was an idea for *knowledge of content and teaching: transnumeration*; she suggested to the students that they represent their sorting of cards in a simple two way table. This new teacher knowledge was successful as her students could understand it and see the clear connection with the sorted data cards. Her trial solution, in response to recognizing a need because of the students, was a successful one for the situation that she had faced.

Types of knowledge that developed through teaching

The examples described above indicate that, through the use of classroom video and follow up interview, evidence could be found for the growth of some types of teacher knowledge. However, the teacher knowledge framework revealed that the categories in which growth occurred were limited to knowledge of content and students, and to a lesser extent, knowledge of content and teaching and specialized knowledge of content. There was no evidence of common knowledge of content being developed. This aspect of knowledge refers to the ability to identify incorrect statistical answers and inaccurate definitions, and the ability to successfully complete statistical investigations (with all the associated transnumeration of data, acknowledgement of variation, reasoning with models, and integration of statistical and contextual knowledge); all of this is what a 'statistically educated person in the street' might be able to do.

Specialized knowledge of content is considered to be the aspects of statistical knowledge that a teacher should have that enables the teacher to analyze from a statistical perspective whether a student's unconventional answer or explanation is justified, or to give a statistical explanation for why a particular process works. This is considered to be statistical knowledge rather than knowledge for teaching per se, but it links to the need to understand students' thinking, especially when it is 'ill formed' and developing. This type of knowledge did not appear to develop during teaching, although it is possible that it was not observed in these lessons and in relation to the framework.

DISCUSSION AND CONCLUSIONS

Of the four types of teacher knowledge (common knowledge of content and specialized knowledge of content; knowledge of content and students and knowledge of content and teaching), only some types were shown to grow during teaching. This development was identified through the use of classroom video and stimulated recall interviews based on selected classroom episodes, when linked to a teacher knowledge framework for teaching statistics.

The necessary conditions for knowledge growth to occur involved firstly the recognition of a problem (Popper, 1979), or a mismatch between the teacher's current knowledge (or theories about students) and the current experience (Swann, 1999b). This was most often in relation to knowledge of content and students–recognition that students were having unexpected difficulties with some aspect of the statistical investigation. As a consequence of this knowledge growth, the teachers generally recognized a new problem, namely a mismatch between their current knowledge of content and teaching and the consideration of what they should do to help students overcome the challenges they were facing. In some cases, the teachers were able to develop a trial solution with a new idea of how to deal with the students' problem from a pedagogical perspective; however there were situations in which the teachers acknowledged that they did not know how to deal with the problem, and so their knowledge of content and teaching, although recognized as being inadequate,

did not develop and the mismatch remained without a tentative solution being developed to replace the original state of knowledge.

The use of classroom video was an essential component in identifying knowledge that was used, and the situations in which knowledge developed. It is clear that teacher knowledge is dynamic, rather than static. Parts of teacher knowledge quite clearly develop through teaching. The stimulated recall interviews provided the opportunity for teachers to observe and reflect on their own teaching. In some instances, the teachers recognized situations relevant to their knowledge and discussed what had been happening, without any prompting from the researcher. There were other episodes viewed in which the teachers did not identify any problem or relevance to their teacher knowledge until they were asked questions by the researcher. Being able to reflect and elaborate on classroom incidents is a learning opportunity for teachers that they would not otherwise have, and is one of the benefits of stimulated recall interviews (Yinger, 1986).

This study has some implications for teacher professional development, whether at the preservice (or initial teacher education) level, or at the inservice (or professional development) level. If certain components of teacher knowledge are not likely to grow while teaching, then consideration must be given to how else such growth might happen. Providing the opportunity for teachers to view video of their own teaching, in a supportive environment where reflection and discussion can take place, enables the teachers to share ideas and interpretations on what happens in the classroom episodes. They also have the opportunity to consider alternative strategies, and to seek advice for future lessons. Other people, such as colleagues or professional development facilitators, are in a position to be able to make suggestions in relation to particular categories of knowledge as they are identified in relation to the teacher knowledge framework.

Common knowledge of content in relation to statistical investigations is unlikely to develop in the classroom. The recommendation for developing this type of knowledge is for teachers to be engaged in their own investigations, through a supportive learning community. Most teachers have not had the opportunity to learn statistics through investigations, because of the relatively recent emphasis in the statistics education literature on such an approach. As their common knowledge of content develops, teachers will have the opportunity for their specialized knowledge of content to develop, particularly as they listen to and attempt to make sense of students' responses, explanations, and questions. Classroom videos showing teachers engaging with and responding to students would provide a useful tool for helping the development of specialized knowledge of content. Also, any interactions with students, either through video or within the context of the classroom, would also have the potential for knowledge of content and students to develop as teachers become aware of what aspects of statistical investigations are challenging for students. When teachers have knowledge of content and students, they then require knowledge of content and teaching in relation to how to address the learning challenges of students.

It was clear within the research that the categories of teacher knowledge do not act in isolation from one other, but are closely connected. Any program of teacher professional development needs to therefore ensure that all categories are targeted in a cohesive and connected way, in order to ensure that teacher knowledge develops effectively.

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